Punctuated Equilibrium or Ambidexterity: Dynamics of Incremental and Radical Organizational Change over Time

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Abstract

Using formal simulation, I examine how environmental turbulence and complexity influence the temporal patterns of incremental and radical organizational change. In stable and simple environments, incremental change is found to be sufficient to keep pace with the task environment. Both turbulence and complexity are found to generate a punctuated equilibrium pattern but with different underlying mechanisms. When both turbulence and complexity are high, the punctuated equilibrium pattern is replaced by a dynamic type of ambidexterity. Implications for managing organizational change are discussed.

JEL classification: C63, D21, O33

1. Introduction

The need for organizations to undertake both incremental, exploitative changes and radical, exploratory changes is widely accepted in the literature (Gupta et al., 2006; He and Wong, 2004; Levinthal and March, 1993; March, 1991; Tushman and O'Reilly, 1996; Uotila et al., 2009; Wang and Li, 2008). However, it is still generally unclear how organizations tend to balance the two types of change over time. Two major models have been suggested: punctuated equilibrium and ambidexterity. In the punctuated equilibrium model, the organization adapts through long periods of exploitative, incremental change punctuated by brief periods of exploratory, radical change (Gersick, 1991; Lant and Mezias, 1992; Miller and Friesen, 1980; Sabherwal et al., 2001; Tushman and O'Reilly, 1996; Tushman and Romanelli, 1985). In contrast, in the ambidexterity model, the organization continuously and simultaneously engages in both exploitative and exploratory adaptation (Benner and Tushman, 2003; Cao et al., 2009; Gibson and Birkinshaw, 2004; He and Wong, 2004; Lubatkin et al., 2006).

Scholars studying the antecedents of punctuated equilibrium or ambidexterity have typically assumed an internal perspective on the organization, examining the strategic and structural factors that allow an organization either to periodically switch between incremental and radical adaptation, as in the punctuated equilibrium model (Boumgarden et al., 2012; Burgelman, 2002; Sastry, 1997), or to simultaneously perform both incremental and radical changes across the organization, as in the ambidexterity model (Benner and Tushman, 2003; Gibson and Birkinshaw, 2004; Kyriakopoulos and Moorman, 2004; O'Reilly and Tushman, 2008). Which of the two temporal patterns of change organizations tend to exhibit, however, is relatively less well understood. The empirical evidence regarding this issue has been mixed (Brown and Eisenhardt, 1997; Romanelli and Tushman, 1994; Venkatraman et al., 2007;

Wischnevsky and Damanpour, 2005), and it is still unclear whether organizations tend to follow the punctuated equilibrium model or the ambidexterity model of adaptation to their environments over time (Boumgarden et al., 2012; Gupta et al., 2006; Lavie et al., 2010).

In this study, I argue that different types of task environments pose different demands on organizational change and that the characteristics of the task environment may influence whether organizations tend to follow the punctuated equilibrium model or the ambidexterity model in their organizational change patterns over time. Using a formal simulation of organizations adapting in different types of NK landscapes (Kauffman, 1993; Levinthal, 1997), I find that either environmental turbulence or environmental complexity can bring about a punctuated equilibrium pattern of incremental versus radical change but the mechanisms that generate such a pattern are different in turbulent environments compared to complex environments. In contrast, ambidexterity emerges as the predominant mode of adaptation in environments that are either simple and stable or highly complex and highly turbulent, although the mode of ambidexterity is different in these two types of environments. I discuss the implications of the simulation results for managing organizational change over time and consider how the results can be used to resolve conflicting empirical evidence regarding the temporal dynamics of organizational change as a response to environmental dynamism.

2. Punctuated equilibrium versus ambidexterity

2.1. Patterns of incremental and radical change over time

To maintain both short-term performance and long-term viability in the face of dynamic environments, organizations must be able to both perform exploitative, incremental changes to refine their current positions and perform exploratory, radical changes when necessary to assume new, potentially superior positions for future exploitation (He and Wong, 2004; March, 1991; Tushman and O'Reilly, 1996; Uotila et al., 2009; Wang and Li, 2008). The processes of incremental and radical change impose conflicting demands on organizations, and a major question in the management literature is how to resolve the tension between the two types of adaptation over time (Andriopoulos and Lewis, 2009; Benner and Tushman, 2003; Fang et al., 2010; Gupta et al., 2006; Lavie et al., 2010; Levinthal and March, 1993; Raisch et al., 2009). Despite the substantial research on this topic, what temporal pattern organizations tend to follow remains a contested issue.

Several scholars have argued that organizations typically evolve according to the punctuated equilibrium model. Punctuated equilibrium was originally developed in evolutionary biology as a model of species evolution (Eldredge and Gould, 1972) and has since been adopted by organizational scholars as a model of how individual organizations can change their structure and processes (Haveman, 1992; Lant and Mezias, 1992; Miller and Friesen, 1980; Romanelli and Tushman, 1994; Sabherwal et al., 2001; Tushman and O'Reilly, 1996; Tushman and Romanelli, 1985). Gupta et al. (2006: 698) define punctuated equilibrium as “temporal cycling between long periods of exploitation and short bursts of exploration.”[1]

The evolution of an organizational system in the punctuated equilibrium model is characterized by long periods of relative stability and equilibrium, punctuated by occasional radical change. Tushman and O’Reilly (1996: 11) argue that “Almost all successful organizations evolve through relatively long periods of incremental change punctuated by environmental shifts and revolutionary change.” During the long equilibrium periods, the basic configuration of the elements of the organizational system, i.e., its “deep structure”, is maintained, and the system remains relatively stable, adapting to its environment only through incremental changes (Gersick, 1991). In the brief periods of revolutionary change, the system's deep structure is disbanded, and radical changes that form the basis for a new deep structure occur.

Although the punctuated equilibrium model of evolution has been argued to be ubiquitous in organizations, the mechanisms and antecedents of this pattern of relative stability punctuated by occasional radical change are still largely unclear, and organizational scholars have debated whether and in what contexts the punctuated equilibrium model is the dominant mode of organizational adaptation (Gupta et al., 2006). Scholars who have studied punctuated equilibrium have typically investigated the consequences of such occasional radical changes to the system under study (e.g., Farjoun, 2007; Lant and Mezias, 1992; Siggelkow, 2002; Wollin, 1999), but the fundamental reasons underlying such a change pattern remain, for the most part, unaddressed. Although the features and correlates of punctuated equilibrium evolution have been discussed by some scholars (e.g., Boumgarden et al., 2012; Gersick, 1991; Gupta et al., 2006; Romanelli and Tushman, 1994), why and when such patterns of change manifest have received relatively little attention.

As an alternative to the punctuated equilibrium model, the ambidexterity model has received increased attention in the recent literature on organizational change. In the ambidexterity model, organizations perform both exploratory and exploitative adaptation simultaneously (Benner and Tushman, 2003; Cao et al., 2009; Gibson and Birkinshaw, 2004; He and Wong, 2004; Lubatkin et al., 2006). The literature on ambidexterity has argued that organizations cannot focus exclusively on exploration or exploitation; instead, they must continuously engage in both types of change. This literature has focused on the internal factors, such as structural arrangements (Benner and Tushman, 2003) and strategic mindsets (Gibson and Birkinshaw, 2004), that allow organizations to explore and exploit simultaneously.

Although punctuated equilibrium and ambidexterity are widely accepted as two alternative mechanisms for balancing incremental and radical change over time, it is not clear whether an organization should follow the punctuated equilibrium model or the ambidexterity model in its long-term change patterns (Gupta et al., 2006; Raisch and Birkinshaw, 2008). Despite the large number of qualitative and anecdotal accounts in the literature (e.g., Brown and Eisenhardt, 1997; Burgelman, 2002; Rindova and Kotha, 2001; Tushman and O'Reilly, 1996), there are few studies that examine which model better describes the actual change patterns observed in organizations. Furthermore, the somewhat inconsistent results produced by these studies (Miller and Friesen, 1980; Romanelli and Tushman, 1994; Venkatraman et al., 2007; Wischnevsky and Damanpour, 2005) suggest that there may be as yet unidentified contextual factors that affect such patterns.

2.2. Role of the task environment

The organization's task environment can be considered a key driver in organizational adaptation (Aldrich, 1999; Dess and Beard, 1984; Wiersema and Bantel, 1993). However, the existing literature on the antecedents of punctuated equilibrium or ambidexterity has largely focused on internal factors, such as routines, structures, and managerial perceptions, that may allow the organization to follow a particular change pattern (e.g., Adler et al., 1999; Benner and Tushman, 2003; Burgelman, 2002; Floyd and Lane, 2000). Apart from the implicit or explicit notion that radical organizational transformations tend to follow radical transformations in the environment (e.g., Lant and Mezias, 1992; Romanelli and Tushman, 1994; Sastry, 1997), the role of the task environment as a determinant of punctuated equilibrium or ambidexterity has been relatively unexplored. However, the existing literature offers some insight into potential factors in the task environment that may influence the organization's change patterns. Two factors are of particular interest: complexity and turbulence.

First, several scholars have considered environmental complexity a key factor in organizational change and adaptation (e.g., Duncan, 1972; Gavetti et al., 2005; Siggelkow and Rivkin, 2005). More specifically, complexity has been argued to limit the potential for local, exploitative adaptation (Levinthal, 1997). In complex task environments, the payoffs from organizational activities are dependent on one another, which makes incremental, exploitative change difficult in high-performing organizations because changes in one activity disturb the more or less optimized payoffs from the other activities. To improve their performance, locally optimized organizations may need to resort to a radical, exploratory transformation, i.e., a "long jump", to find a new internally coherent set of activities that provides improved performance.

Further, as Levinthal (1997: 938) argues, "a successful long-jump provides a renewed opportunity for local adaptation," thus improving the viability of subsequent incremental change. Incremental, exploitative adaptation, on the other hand, decreases the probability of such long jumps because the better optimized the organization's activities are, the more difficult it is to find completely new but better methods of doing things (Levinthal, 1997), and the organization can end up in a "competency trap" in which its high level of expertise in sub-optimal activities disincentivizes it from exploring potentially better alternatives (Levinthal and March, 1993; Levitt and March, 1988). This dynamic in which exploitative, incremental change makes exploratory, radical change both more difficult and more important over time, whereas exploration can renew the organization's potential for exploitation, could be hypothesized to lead to a temporal pattern in which long periods of exploitation are punctuated with brief periods of exploration. Thus, complexity may be an important factor in driving the temporal patterns of exploration and exploitation.

Second, environmental turbulence, i.e., the rate of change in the environment, has frequently been considered central in the literature on organizational change (e.g., Duncan, 1972; Jansen et al., 2006; March, 1991; Siggelkow and Rivkin, 2005). In a fast-changing environment, the organization must increase its exploration efforts when incremental, exploitative adaptation is not sufficient to keep pace with the changing environment (March, 1991). Thus, environmental turbulence can be expected to increase the need for exploration and radical change, although it is not obvious whether this increase in exploration takes the form of occasional radical transformations interspersed in longer periods of incremental change, as in punctuated equilibrium, or whether the increased exploration activity is performed concurrently with exploitative adaptation, as in the ambidexterity model.

Furthermore, it is unclear how turbulence and complexity jointly influence the temporal patterns of exploration and exploitation. Levinthal (1997) finds that complexity makes responding to an environmental change through incremental adaptation more difficult, which suggests that complexity may intensify the effect of turbulence on the need for exploratory, radical change; however, whether such dynamics would bring about a punctuated equilibrium or an ambidexterity model of balancing exploration and exploitation is uncertain. To illuminate how the organization's task environment influences how organizations balance the two types of change over time, I next conduct a theoretical investigation of these issues using a formal simulation model of organizational adaptation.

3. Method

To examine the temporal patterns of exploratory versus exploitative adaptation in different task environments, I employ the NK framework (Kauffman, 1993; Levinthal, 1997), a simulation model of complex adaptive systems that has been widely used in the recent management literature (Almirall and Casadesus-Masanell, 2010; Frenken, 2000; Gavetti and Levinthal, 2000; Lenox et al., 2006, 2007; Rivkin, 2000, 2001; Siggelkow and Rivkin, 2005; Sommer and Loch, 2004). Because the NK model reflects the tension between the need for local, exploitative adaptation and the benefits of identifying favorable distant regions in the adaptation landscape through exploratory, radical change, the model has been used to examine a variety of issues related to the exploration–exploitation balance in organizational search and adaptation (Fang and Levinthal, 2009; Lazer and Friedman, 2007; Rivkin and Siggelkow, 2003, 2007; Siggelkow and Levinthal, 2003; Siggelkow and Rivkin, 2006). Further, because the NK model readily allows for modeling the effects of both environmental turbulence and environmental complexity on the adaptation processes of an organization (Levinthal, 1997), it is an ideal framework for examining the effects of the task environment on the temporal patterns of balancing exploration and exploitation.

The full pseudocode of the NK model used in the present study is provided in the Supplementary Appendix. The organization, denoted by letter O, is modeled as adapting in an N-dimensional adaptation landscape, representing the organization's task environment. In this landscape, the organization is faced with N distinct decision elements, representing the choices that the organization must make regarding its markets, products, technologies, distribution systems, etc. The organization O is modeled as an N-dimensional vector of choices e_n, i.e., $O = (e_1, e_2, \ldots, e_N)$. This vector represents the organization's choices on each of these choice dimensions and, thus, its position in the NK landscape. Following the standard NK framework, each choice element can take the value of 0 or 1.[2]

The performance contribution of each organizational choice is dependent on not only the choice itself but also the organization's choices regarding K other randomly assigned decision elements. Formally, the performance contribution P_n of decision element n is drawn from the uniform distribution U[0, 1] for each combination of binary values of the decision element n itself and of the binary values of its K interacting elements, i.e., $P_n = f_n (e_n; e_{n1}, \ldots, e_{nK})$, where e_n is the value of decision element n, e_{nk} is the value of the k-th interacting decision element for element n, and f_n is a function that provides a randomly initialized value from U[0, 1] for each different combination of binary argument values. The overall performance, or fitness, of the organization is the average of the performance contributions of all of its N choices.

At the beginning of the simulation, the organization is assigned a random vector of initial decision values. From this random position in the landscape, the organization begins the process of scanning its task environment and implementing the changes that are necessary to adapt to this environment. To examine the pattern of incremental versus radical change over time, I allow the organization to sample both local and distant landscape positions in each time period. Thus, in the simulations presented below, the organization examines, in each time period, the potential performance contribution of a number of local landscape positions, i.e., positions that the organization can achieve by making a different choice regarding a single decision element, and a number of distant landscape positions, i.e., random vectors of decisions that can require simultaneous changes in up to N choices. If the organization locates a landscape position that offers better performance than its current position, then the organization changes to this new position. If the organization finds the new position through local search, then it adapts through incremental, exploitative adjustment, only changing the one decision necessary for it to attain the new position. However, if the organization finds the new position through distant search, then the change requires a radical, exploratory transformation entailing a change in multiple decision elements.

In the NK framework, the N choices made by the organization are interdependent, and the value of each decision depends on how the organization has resolved K other decisions. Therefore, the parameter K denotes the complexity of the organization's task environment. Landscapes with high K are rugged with multiple local peaks, i.e., landscape positions that may not be globally optimal but at which changing the binary choice for any single decision element would lower the organization's overall performance due to the interdependencies between the elements (Levinthal, 1997). I vary the parameter K in the simulations to examine how patterns of organizational adaptation are influenced by the complexity of the task environment and the corresponding ruggedness of the adaptation landscape.[3]

To examine the influence of varying rates of environmental turbulence on the adaptation processes in NK landscapes, I use the parameter T to denote the probability of environmental change. In each time period, for each decision element n, there is a probability T that the performance function f_n is reinitialized for all potential combinations of argument values for that particular decision element. Therefore, T represents the average rate of change in any single decision element, and higher levels of T imply higher levels of environmental turbulence.

To analyze when and why a typical organization follows the punctuated equilibrium model or the ambidexterity model of incremental and radical change over time, I simulated the adaptation of a model organization to a number of task environments with N = 20 decision elements, with different values of turbulence T and complexity K. I used the same search strategy in each environment, consisting of three local and three distant search trials per time period. In each time period, the organization first performed up to three local search attempts and made an incremental improvement if it identified a local landscape position that improved its fitness. If the organization identified a superior local position in one of the three attempts, then it stopped the process of local search for that time period. Regardless of whether the local search was successful, the organization then conducted up to three distant search attempts and made a long jump to a superior distant position if it found one, similarly stopping its distant search when a superior position was found. The analyses presented in the following section provide descriptive, comparative accounts of how the adaptation processes of a typical organization were found to unfold in different types of task environments.

4. Turbulence, complexity, and regimes of adaptation

The following four figures depict the first 300 time periods in one simulation run for an organization adapting to a task environment that is either simple (K = 0) or complex (K = 16), and either slow-moving (T = 0.005) or fast-moving (T = 0.025). In the figures, the light gray bars show the fitness level of the organization. The black bars depict how much potential the organization has for local, incremental improvement, denoting the number of landscape positions that the organization would be able to attain by changing a single decision element and that would yield a better fitness value than the organization exhibits at that point in time. The dark gray bars that cross the figures vertically depict periods in which the organization performs a radical transformation, i.e., an exploratory "long jump." Incremental improvements are relatively common and, for clarity, are omitted in the figures.

Each run depicted in Figures 1 to 4 consists of 900 data points. In each of the 300 time periods, the graphs show three successive values for both organizational fitness and the potential for local improvement: first, the values that apply before the organization has made any changes; second, the values that the organization attains after local search and possible incremental change but before distant search and possible radical change; and third, the values that the organization attains after all of its search efforts for the period. Between time periods, the environment potentially changes, and the fitness value for each individual decision element is randomly redrawn with a probability T. Because the organization only proactively initiates changes that improve its fitness, all decreases in fitness that can be observed in the figures stem from the task environment's changing due to turbulence.

Insert Figure 1 about here

Figure 1 shows the adaptation dynamics in a landscape with low complexity (K = 0) and low turbulence (T = 0.005). With these parameter values, there can be expected to be, on average, a change in at least one environmental dimension in slightly less than ten percent of the time periods.[4] As shown in the figure, the organization begins the simulation with a relatively low fitness level and high potential for local improvement. Through its adaptation efforts, the organization improves its configuration of choice elements and quickly reaches the global peak in the landscape. Correspondingly, the potential for local improvement quickly reaches zero, and it stays low for the remainder of the simulation. Only when environmental changes move the global peak to a slightly different position in the landscape do the potential and need for improvement again emerge. However, due to the relatively low level of turbulence, the organization is able to quickly reach the new global peak through incremental adaptation.

Radical transformations occur only at the beginning of the simulation, when the organization is still far from the optimal combination of choice elements. After the organization reaches the peak in the landscape, its long-term adaptation process is characterized by continuous incremental adjustments to the environment. In the long term, i.e., after the first 100 time periods, incremental adjustments follow environmental changes, occurring in approximately six percent of the time periods. When environmental change forces the organization to change along many dimensions, i.e., to explore distant regions in the landscape, the slow pace of environmental change and the simplicity of the landscape allow the organization to do so via the simple accumulation of incremental, exploitative changes. Thus, exploratory search becomes simply an accumulation of exploitative search, and the organization engages in a form of ambidexterity that allows it to combine exploration and exploitation such that the two are, in principle, indistinguishable. Because of the relative stability of the fitness level of the organization and the lack of radical transformations, I call this mode of adaptation "stable ambidexterity."

Insert Figure 2 about here

The first 300 periods of the adaptation process in a landscape with low complexity (K = 0) and high turbulence (T = 0.025) are depicted in Figure 2. With these parameter values, there is a change in at least one environmental dimension in approximately 40 percent of the time periods. As in the simple and slow-moving landscape, in this simple and fast-moving landscape, the organization also begins with relatively low fitness and quickly adapts toward the global peak. However, because the environment changes rapidly, the peak also frequently changes its position in the landscape, creating the need for local improvement. The potential for local improvement remains higher than that in a stable environment, and the organization engages in continuous exploitative adaptation, with incremental adjustments continuing to occur in approximately 27 percent of the time periods with these parameter values.

As also shown in Figure 2, the environment occasionally changes too rapidly for the organization to react via exploitative adaptation alone. In such cases, the potential for local improvement increases as the fitness of the organization decreases. The low level of fitness triggers radical transformations, which typically occur when the organization has drifted far from the peak in the landscape. These radical transformations can therefore be interpreted as attempts to "catch up" with the environment when the rate of exploitative adaptation, even if high, is not sufficient in responding to the rapidly cumulating environmental change. Because the adaptation process is characterized by relatively long periods during which the organization is able to stay at or near the peak through exploitative, incremental adjustments but these periods are interspersed with exploratory, radical transformations that occasionally occur in response to bursts of environmental turbulence, I name this mode of adaptation "catch-up punctuated equilibrium."

Insert Figure 3 about here

In a complex (K = 16) and low-turbulence (T = 0.005) environment, as depicted in Figure 3, the adaptation pattern is somewhat similar, but its antecedents are different. In such an environment, radical transformations are also a response to the decreasing fitness levels that occur when environmental changes make the organization's position in the landscape suboptimal. However, comparing Figures 2 and 3, one can observe that this environment differs from a simple and fast-moving environment in that when radical transformations occur, the organization typically resides at or near a local peak with little to no potential for incremental improvement. Whereas there is only a single peak in a simple landscape, which moves due to environmental turbulence, in a complex landscape, there are a multitude of peaks with varying fitness levels. Because the organization's incremental adaptation efforts are constrained by the complex structure of interactions between the decision elements, the organization must undertake a radical transformation to escape the obsolete and now low-performing local peak at which it is stuck.

These structural constraints to incremental adaptation are also reflected in the long-term rate of incremental adaptation, which is even lower than in the "stable ambidexterity" regime, with incremental adjustments occurring in approximately four percent of the time periods with these parameter values. In a complex landscape, the basins of attraction around the peaks are small, and the potential for local search is quickly exhausted. This scenario creates punctuated equilibrium dynamics such as those depicted in Figure 3: the organization uses exploitative, incremental changes to remain at a local peak for an extended period of time, jumping toward another peak through an exploratory, radical transformation when the fitness level at the old peak falls too low. Because this type of punctuated equilibrium is necessitated by the structural constraints on continuous incremental adaptation, I name this mode of adaptation "structural punctuated equilibrium."

Insert Figure 4 about here

Finally, Figure 4 shows how the adaptation process unfolds in a complex (K = 16) and highly turbulent (T = 0.025) landscape. Because the environment changes rapidly in this scenario, any advantage that the organization gains by reaching a local peak through incremental change is short-lived. Additionally, because the environment is also highly complex, the rapidly changing high-performance peaks cannot be attained by incremental adaptation alone, and radical transformation is a frequent occurrence. However, these radical changes do not occur at the expense of exploitative adaptation; on the contrary, in the long term, incremental adjustments occur in approximately 14 percent of the time periods with these parameter values, over double the rate of incremental adaptation found in the "stable ambidexterity" regime. The organization thus engages in constant radical transformations in its search for the newest high peak, in addition to incremental adaptation efforts to optimize toward these peaks before they become obsolete. Because the organization engages in an ambidextrous process of dynamically balancing exploratory and exploitative change in which the two activities occur separately but simultaneously, I name this mode of adaptation "dynamic ambidexterity."

To further illustrate how the four modes of adaptation discussed above are influenced by the characteristics of the task environment, Figure 5 shows how the temporal pattern of adaptation in an organization that engages in three local and distant search attempts in each time period depends on environmental turbulence and complexity. Although the adaptation regime changes somewhat smoothly as turbulence and complexity change, for simplicity, I have divided the modes of adaptation into the four abovementioned categories based on, first, how often the radical transformations occur and, second, whether the radical transformations typically occur when the organization resides far from a local peak in the landscape and thus also has much potential for local improvement or whether they occur when the organization is at or near a local peak and thus has little potential for local improvement and requires a radical transformation to change at all.

To create Figure 5, I varied turbulence, in increments of 0.002, from T = 0.002 to T = 0.030 and complexity from K = 0 to K = 16. For each set of parameter values, I ran 100 simulation runs of 1000 time periods each.[5] I calculated the average number of radical transformations per 1000 time periods, and when a radical transformation (long jump) occurred, I also calculated the number of potential local improvements that the organization had before the long jump, i.e., the choice dimensions on which it could have also improved through incremental adaptation. To analyze the long-term evolutionary patterns, I ignored the first 100 time periods in each simulation run and only included periods 101–1100 in the averages. The complexity–turbulence parameter combinations that led to very infrequent radical changes (less than 4 in 1000 periods) are coded as “stable ambidexterity,” and the combinations in which radical changes were very frequent (more than 30 in 1000 periods) are coded as “dynamic ambidexterity.” When radical transformations only occurred occasionally (from 4 to 30 in 1000 periods), the adaptation regime is referred to as a “punctuated equilibrium.” In the figure, the punctuated equilibrium regime is further divided in two such that if, immediately before a radical transformation, the organization had an average of two or more potential local improvements, the cell is coded as “catch-up punctuated equilibrium” and, if there were less than two potential dimensions for incremental improvement, the cell is coded as “structural punctuated equilibrium.”

Insert Figure 5 about here

As shown in Figure 5, when both turbulence and complexity are low, the organization engages in stable, ambidextrous adaptation; its exploration and exploitation needs are both fulfilled via continuous incremental change. When turbulence is high but complexity remains low, the organization follows a punctuated equilibrium model in which it requires the occasional exploratory, radical change to cope with environmental changes that shift it too far from the peak. Conversely, landscapes with low turbulence and high complexity pose structural constraints on continuous incremental adaptation, and the organization must occasionally alleviate these constraints through a radical transformation, again producing a punctuated equilibrium pattern. Finally, in adaptation environments that are both highly complex and highly turbulent, the organization engages in a dynamic form of ambidexterity that combines continuous exploration efforts to find new, better, short-lived peaks and continuous exploitation efforts to capitalize on these peaks before they disappear.

Because the probability of a long jump is proportional to the number of landscape positions with a higher fitness value than the organization's current position, long jumps tend to occur as a response to the failure of local search to reach high-performing landscape positions. The results suggest that there are two distinct reasons why local search may fail: either it is not fast enough to keep up with the rapidly changing environment or the firm is stuck on a local peak and cannot improve further through local search alone. Because radical transformations tend to be risky to the organization (Amburgey et al., 1993; Hannan and Freeman, 1984), it may want to reduce the need for such transformations, and the two dynamics have different implications for whether and how the need for long jumps can be reduced.

To illustrate these differences, I experimented with two sets of parameter values from Figure 5: Case A, with K = 0 and T = 0.03 in the catch-up punctuated equilibrium regime, and

Case B, with K = 16 and T = 0.002 in the structural punctuated equilibrium regime. Both sets of parameter values yielded the same probability of radical transformation, on average 11 long jumps in 1000 time periods, when the organization could perform three local and three distant search attempts each turn. However, in Case A, increasing the number of local search attempts per turn from three to ten reduced the number of long jumps by almost 90% down to 1.3 in 1000 periods, moving the organization to the stable ambidexterity regime, whereas a similar increase in local search in Case B had little effect, with the average number of long jumps dropping only by 10% to 9.7 per 1000 periods. Thus, in the case of catch-up punctuated equilibrium, increasing the speed of incremental search can help the organization stay at the peak and reduce the need for long jumps, whereas in the case of structural punctuated equilibrium, the structural constraints prevent incremental adaptation altogether, and increasing local search efforts does little to alleviate the need for radical transformation.

I also examined whether the nature of the environmental turbulence has an influence on the adaptation dynamics. Specifically, I experimented with incorporating an additional parameter S to indicate the severity of environmental changes so that each time a change occurred, the fitness values for S randomly chosen decision elements were redrawn. Keeping the total rate of change, i.e., the change frequency multiplied by severity, constant facilitated a comparison of the effects of gradual versus sudden change, all other things being equal. These experiments suggest that although the total rate of change is the most important determinant of adaptation dynamics, environmental change that occurs in short bursts rather than gradually also influences these dynamics by generally making the catch-up punctuated equilibrium a more likely scenario. Conversely, the structural constraints that inhibit local adaptation appear to be a more salient concern when the organization faces an environment with gradually accumulating change.

5. Discussion

5.1. Dynamics of incremental versus radical change

The results of the simulations suggest that the temporal dynamics of incremental and radical change may be influenced by the characteristics of the organization's task environment. Figure 6 summarizes the simulation results regarding the four different modes of balancing exploratory, radical change and exploitative, incremental change over time, based on whether the environment is stable or turbulent and whether the environment is simple or complex.

Insert Figure 6 about here

In environments characterized by relatively low levels of turbulence and complexity, balancing exploratory and exploitative adaptation over time is not found to pose a significant problem for organizations. The scarcity of interdependencies between the decision elements cause the task environment to be highly modular (Marengo et al., 2000; Sanchez and Mahoney, 1996), and the organization is able to perform major transformations via multiple minor adjustments. Exploratory change thus occurs as a simple extension of exploitative, local adaptation over time. Such dynamics may be reflected, for example, in the study on the banking industry during the 1975–1995 period by Wischnevsky and Damanpour (2005), who find that many banks were able to respond to major environmental shifts through a series of incremental adaptations. Wischnevsky and Damanpour suggest that such adaptation patterns may have been possible due to the relatively low level of environmental turbulence in the banking industry during the period of observation. The simulation results in the present paper support their findings and suggest that another key factor driving such patterns may have been a relatively low level of environmental complexity: in this particular industry, the low level of interdependence between the key decision elements may have allowed these organizations to adjust to the environment one step at a time. Thus, such a task environment may allow for a stable form of ambidexterity in which both exploration and exploitation can be performed through continuous incremental adjustment.[6]

When the task environment is simple but turbulent, radical transformations are found to follow from abrupt bursts of environmental change. Such an underlying mechanism is implicit in many theoretical accounts of the punctuated equilibrium model of evolution that view radical transformations in organizations as an adaptive response to radical transformations in the task environment. Some of these accounts impose no structural limitations on the adaptive responses of the organization (Kim and Rhee, 2009; Lant and Mezias, 1992), and those that explicitly address structural constraints typically consider only such constraints as structural inertia that hinders the organization's ability to respond to radical environmental change rather than view them as a reason for the temporal pattern of adaptation itself (Sastry, 1997; Siggelkow and Levinthal, 2003). Thus, many theoretical accounts of punctuated equilibrium evolution most closely resemble the catch-up model.

This model is also consistent with the punctuated equilibrium pattern discussed in the literature on technological discontinuities, in which abrupt technological changes in the task environment raise the bar and force organizations to perform radical transformations to keep pace with environmental changes (Tushman and Anderson, 1986). For example, the emergence of the Internet has radically increased the turbulence of the task environment faced by newspaper publishers and brought about rapidly accumulating changes in several decision elements related to the acquisition, processing, and delivery of content (Smith et al., 2010). The sheer rate of these changes has made incremental adaptation insufficient for catching up with the task environment and prompted newspaper publishers to perform exploratory search, for example, using separate online units, to find new business models that would realign their activities with the demands of their business landscape.

The pure form of structurally driven punctuated equilibrium evolution is found to occur in complex environments that change slowly enough to allow organizations to develop a high level of competence in their local region of the adaptation landscape. The relative stability of the environment gives the organization sufficient time to reach a local peak and thus develop a “competency trap” (Levinthal and March, 1993; Levitt and March, 1988) in which the organization’s close alignment with the demands of its local environment prevents it from experimenting with more distant alternatives. However, as the environment slowly but inevitably changes, the organization’s locally optimal performance becomes increasingly less optimal in the global sense. The complexity of the task environment and the consequent interdependencies between several decision elements prevent the organization from reaching better-performing regions in the new landscape through incremental adaptation. When faced with declining performance, the organization will eventually be forced to perform a radical transformation that takes it to a new region in the landscape where the organization can again start the process of incrementally improving toward a new peak.

This pattern of balancing exploratory and exploitative adaptation is evident in many studies of punctuated equilibrium evolution (e.g., Romanelli and Tushman, 1994; Siggelkow, 2001; Tushman et al., 1986; Tushman and O'Reilly, 1996). Tushman and O’Reilly (1996) argue that an organization’s success in its existing environment may breed failure in a changing environment in which the organization’s current competencies are becoming obsolete; they suggest that such dynamics occurred in the semiconductor industry, in which the technological basis moved from vacuum tubes to transistors, from transistors to semiconductors, from semiconductors to integrated circuits, etc., with each transition presenting significant challenges for the industry leaders at the time. The need to maintain congruence between the elements of the complex organizational systems created structural inertia that prevented the organizations from adapting to the new environment through incremental change. Thus, to survive, organizations facing such contexts may eventually need to conduct radical transformations that result in a pattern of punctuated equilibrium in the long-term evolution of the organization (Tushman and O'Reilly, 1996).

Siggelkow’s (2001) case study of Liz Claiborne provides a vivid example of how the interactions among the company’s choices regarding its product, marketing, production, and distribution elements made incremental adaptation to the accumulating environmental demands impossible. Liz Claiborne’s choices of a mix-and-match design in clothes, collection presentation in marketing, low-cost overseas supply system and rigid retailer policies all supported one another. Facing a changing retail environment, the company was unable to change this one element without disrupting the others, and it was eventually forced to perform a radical reorientation of the entire company toward a new peak in the landscape.

Although, in practice, both complexity and turbulence may be present to varying degrees in punctuated equilibrium regimes, the structural punctuated equilibrium model presents a fundamentally different underlying dynamic compared to the catch-up model of punctuated equilibrium. However, the existing research does not reflect this distinction, and the two drivers are frequently confounded. For instance, Tushman, Newman, and Romanelli (1986) argue that the punctuated equilibrium model in organizations is driven by a punctuated change pattern in the environment, stating that radical organizational change occurs as a response to radical environmental change. However, their discussion of their empirical examples seems to suggest the presence of structural drivers in their punctuated equilibrium model; they note, for example, that in periods of convergent organizational change, "structures and systems become so interlinked that they only allow compatible changes" (Tushman et al., 1986: 587) and that in a radical reorientation, the "pieces of the revitalized organization pull together, as opposed to piecemeal change where one part of the new organization is out of synch with the old organization" (Tushman et al., 1986: 590). Thus, although their study can be argued to provide a model example of the structural punctuated equilibrium model, they – similar to many other scholars of punctuated equilibrium – attribute the change pattern to catch-up dynamics. As discussed in the next section, the catch-up and structural models of punctuated equilibrium present different managerial challenges, and therefore, they should be recognized as two different drivers of punctuated equilibrium.

The fourth mode of adaptation, dynamic ambidexterity, is found to occur in task environments with high levels of both complexity and turbulence. Brown and Eisenhardt's (1997) study of continuously changing firms in the high-velocity computer industry and Rindova and Kotha's (2001) study of the "continuous morphing" of the Internet firms Yahoo and Excite may provide real-world examples of firms facing such environments. As these case studies suggest, the firms in these industries faced a rapidly changing, highly turbulent environment that forced them to continuously adapt to keep pace with competitive demands. Simultaneously, the task environment of these companies was also highly complex, with numerous interdependencies between strategic and structural elements. This combination of turbulence and complexity may have forced the organizations to continuously engage in a combination of incremental and radical changes, frequently changing several of their strategic and structural characteristics simultaneously. In environments requiring this incessant balance between the potentially conflicting activities of exploratory and exploitative adaptation, the development of sufficient dynamic capabilities may be a critical factor in facilitating such a dynamic form of organizational ambidexterity (Ancona et al., 2001; O'Reilly and Tushman, 2008).

The results of this paper show that environmental contingencies may affect how organizations balance exploratory and exploitative adaptation over time and may thus be helpful in resolving contradicting empirical findings regarding patterns of organizational transformation. For example, in their study of the late 1960s minicomputer industry, Romanelli and Tushman (1994) find that incremental changes did not accumulate to produce significant organizational transformations; instead, significant transformations of minicomputer firms occurred only through punctuational, radical change. In contrast, Wischnevsky and Damanpour (2005), replicating Romanelli and Tushman’s study in the context of the banking industry, find that although punctuational, radical transformations occasionally occurred, banking organizations also frequently reoriented themselves through cumulative, incremental changes.

The models presented in this paper suggest that a key factor driving these differences may have been the different rates of change and different interaction structures in the task environments of the minicomputer industry and the banking industry. If the 1975–1995 banking industry was characterized by a relatively slow-moving task environment in which the different choice dimensions were relatively more independent, whereas the minicomputer industry was characterized by higher rates of turbulence or a tighter web of interdependencies between the decision elements, the results of this paper suggest that these environmental factors may have caused minicomputer organizations to follow the punctuated equilibrium model of evolution much more closely than banking organizations.

On the other hand, in their study of the 1990s computer industry, Brown and Eisenhardt (1997) find that the successful firms in such an environment also did not follow the punctuated equilibrium model; rather, they engaged in "frequent, relentless, and endemic change" (Brown and Eisenhardt, 1997: 32). This industry was ostensibly even more turbulent and complex than the 1960s minicomputer industry, and the models presented in this paper suggest that the punctuated equilibrium pattern among successful organizations may break down in such an environment for the opposite reasons than those that influenced the banking industry, resulting in a dynamic form of ambidexterity. Thus, the conflicting empirical findings presented in the literature would serve not to challenge the validity of the punctuated equilibrium or ambidexterity models but, rather, to illuminate their boundary conditions.

5.2. Managerial implications

Understanding the drivers behind the different temporal patterns of adaptation can be important for optimally managing organizational change processes over time. Because radical transformations can entail significant costs and the risk of failure (Amburgey et al., 1993; Hannan and Freeman, 1984), they should be a major consideration for organizations adapting in punctuated equilibrium regimes. Understanding the antecedents of such transformations can allow organizations to better anticipate, manage, or avoid them. The key drivers of catch-up punctuated equilibrium are different from the key drivers of structural punctuated equilibrium, and whether the need for radical transformations is driven by environmental turbulence or complexity can have major implications for how organizational change should be managed over time.

As shown in Figure 2, under catch-up punctuated equilibrium, radical change typically occurs as a response to the decreasing fitness levels that occur when the organization has drifted far from the rapidly moving peak in the landscape. This finding suggests that in such environments, the need for radical transformations can be avoided if the organization consistently stays sufficiently close to the peak, even when facing rapid environmental change. Doing so requires constant, incremental fine-tuning of individual decision elements, a high level of organizational flexibility, and the ability to perform rapid, incremental adjustments in response to frequent environmental changes (Nadkarni and Narayanan, 2007; Volberda, 1996). Due to the relatively low degree of interdependence between the decision elements, it may be possible to delegate the responsibility for such local flexibility to lower levels in the organizational hierarchy (Tushman et al., 1986). Sufficiently flexible organizations under the catch-up punctuated equilibrium regime may thus be able to postpone radical transformations or even avoid the need to perform such transformations altogether.

However, the simulation results suggest that when the punctuated equilibrium pattern is driven by structural constraints on incremental adaptation, such local responsiveness may be insufficient to avoid the need for radical reorientation, and the organization may need to find other methods to address the adaptive problems presented by task interdependencies. In the models presented above, the interdependencies between decision elements were considered as given, but to the extent that organizations can reduce task interdependencies through, for example, modularization (Schilling and Steensma, 2001; Worren et al., 2002), they may be able to reduce the complexity that they face and thus move from structural punctuated equilibrium to stable ambidexterity. However, to the extent that complexity is unavoidable, organizations may have to anticipate the need for radical reorientation and initiate such reorientations proactively when the first symptoms of obsolescence become visible, rather than waiting to experience the inevitable decline in performance (Tushman et al., 1986). Under structural punctuated equilibrium, the decline in fitness occurs as a steady but inevitable decrease in the performance associated with the organization's local peak rather than due to an abrupt shift in the environment, as under catch-up punctuated equilibrium. Thus, an organization in a complex but relatively slow-moving environment may be able to avoid prolonged periods of low fitness if it initiates radical transformations proactively rather than only when it is forced to do so. Active leadership by top management may be vital in effectively managing such radical reorientations that require concurrent changes in a large number of interacting decision elements (Tushman et al., 1986).

The dynamic ambidexterity regime presents further challenges to organizational adaptability. Although local responsiveness, modularization, and proactive change can also be important considerations under dynamic ambidexterity, the constant need for high levels of both exploratory and exploitative change may necessitate organizational structures and strategies that facilitate the simultaneous pursuit of both (Lavie et al., 2010). Ambidexterity research has identified a variety of methods of managing the tension between exploration and exploitation, including the structural separation of exploratory and exploitative units (Benner and Tushman, 2003; Jansen et al., 2009) and the development of higher-order "meta-capabilities" required for the simultaneous pursuit of exploration and exploitation (Gibson and Birkinshaw, 2004). Building appropriate dynamic capabilities to facilitate both constant exploration and constant exploitation may be vital for organizations facing high levels of turbulence and complexity (O'Reilly and Tushman, 2008).

5.3. Limitations and future research

There are limitations and simplifying assumptions in the model presented here that open up avenues for future research and theorizing. First, the assumption of constant levels of environmental turbulence and environmental complexity may be unrealistic. Although the assumption of constant turbulence was helpful in endogenizing the punctuated equilibrium dynamics, industries frequently vary in their level of turbulence over time (Klepper, 1997), and such temporally varying environmental change can exert different types of influence on adaptive systems on different time scales (Simons, 2002). The complexity of the task environment may also change over time, for example, when technological development enables modularization and reduces the need for tradeoffs, thus reducing the interdependencies between decision elements as the industry matures (Almirall and Casadesus-Masanell, 2010). As argued by Farjoun (2007), such a decrease in turbulence and complexity may have occurred in the Internet portals industry, which, having once served as a model example of an environment requiring constant organizational transformation (Rindova and Kotha, 2001), has since stabilized. Thus, the temporal pattern of adaptation may depend on the time frame used. For example, an organization that follows the dynamic ambidexterity model in the short term may be observed to follow a punctuated equilibrium model when viewed from a longer time perspective. Future research can thus investigate how the dynamics of adaptation illustrated in the present study change in environments characterized by varying patterns of turbulence and complexity and how the time frame affects the analysis of temporal patterns of organizational adaptation.

Second, the above analysis shows that the interaction structure between decision elements is a major determinant of whether the organization follows the punctuated equilibrium or the ambidexterity model of balancing exploration and exploitation. Some scholars have speculated about the link between interdependencies that constrain adaptation and the punctuated equilibrium model of evolution (Miller and Friesen, 1980; Romanelli and Tushman, 1994), whereas others have argued that organizational core elements change mainly through radical transformations (Gersick, 1991; Siggelkow, 2002). Nevertheless, there has been little theoretical analysis of the specific processes linking the interaction structure of the task environment and the punctuated equilibrium model of evolution. In this study, I have only examined how the absolute level of complexity (i.e., interaction density) affects these processes. In real organizational systems, different decision elements may have different degrees of interactional centrality, and these elements may be organized in different hierarchical structures. For example, Wollin (1999) discusses the dynamics of punctuated equilibrium in systems with numerous nested levels of elements and argues that, in such systems, incremental change occurs at more marginal levels and that increasingly radical change occurs due to changes in increasingly fundamental levels. Studying the effects of different types of hierarchical interaction patterns between decision elements, such as nested hierarchies (Wollin, 1999) and modular structures (Ethiraj and Levinthal, 2004), may provide further insight into the evolutionary dynamics of complex organizational systems.

Third, the focus of this study was the descriptive analysis of the patterns of exploratory and exploitative adaptation that emerge in organizational systems facing environmental turbulence and complexity. Thus, this study has not addressed the specific organizational strategies or processes that facilitate different types of adaptive patterns, such as the ability to pursue exploration and exploitation simultaneously in an ambidextrous organization (Andriopoulos and Lewis, 2009; Benner and Tushman, 2003; Gibson and Birkinshaw, 2004; Kyriakopoulos and Moorman, 2004; O'Reilly and Tushman, 2008) or the ability to switch between exploration and exploitation over time to periodically perform the radical transitions necessary for punctuated equilibrium evolution (Burgelman, 2002; Sastry, 1997; Siggelkow and Levinthal, 2003). Further, I have assumed that the organization is able to accurately evaluate the landscape positions that it samples; in reality, such "off-line" evaluation of alternatives may not always be possible, particularly with long jumps that the firm may need to implement before uncovering their full performance implications, and future research can examine how the introduction of such uncertainty in the evaluation of choice configurations may change the organization's adaptation patterns over time (e.g., Gavetti and Levinthal, 2000; Knudsen and Levinthal, 2007). I have also analyzed the adapting organization as a stand-alone actor and ignored the possibility of the organization's using external linkages such as strategic alliances to balance exploration and exploitation (Lavie and Rosenkopf, 2006; Lin et al., 2007; Rothaermel and Deeds, 2004; Schildt et al., 2005). Thus, how the internal processes and capabilities of the organization, in addition to potential interorganizational arrangements, affect the exploration–exploitation balance over time warrants further attention.

6. Conclusion

The results of this study suggest that the turbulence and complexity of the task environment may influence whether an organization follows a punctuated equilibrium or an ambidexterity model in balancing radical and incremental change, or exploration and exploitation. The simulation models suggest that there are two different types of punctuated equilibrium: catch-up and structural. In the catch-up punctuated equilibrium regime found in simple and fast-moving environments, long periods of exploitative adaptation are interspersed with short bursts of exploratory adaptation that are necessary to keep pace with rapidly accumulating environmental demands. In contrast, in the structural punctuated equilibrium regime found in complex and slow-moving environments, the reason for the occasional bursts of exploration is the need to periodically escape suboptimal stable equilibria. Furthermore, ambidexterity is the dominant pattern of adaptation in two types of task environments: in environments that are sufficiently simple and stable to make ambidexterity effortless, resulting in stable ambidexterity regimes in which exploratory adaptation occurs through a series of exploitative adaptive steps; and in environments that are sufficiently complex and turbulent to make ambidexterity a necessity, creating a dynamic ambidexterity regime in which distinct acts of exploratory and exploitative adaptation are constantly present. I hope that these results will be useful in reconciling the discrepant empirical and theoretical arguments and furthering the literature on organizational change patterns over time.

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References

Adler, P. S., B. Goldoftas and D. I. Levine (1999), 'Flexibility versus efficiency? A case study of model changeovers in the Toyota Production System,' *Organization Science,* **10**, 43-68.

Aldrich, H. E. (1999), *Organizations Evolving.* Sage: Thousand Oaks, CA.

Almirall, E. and R. Casadesus-Masanell (2010), 'Open versus closed innovation: a model of discovery and divergence,' *Academy of Management Review,* **35**, 27-47.

Amburgey, T. L., D. Kelly and W. P. Barnett (1993), 'Resetting the clock: the dynamics of organizational change and failure,' *Administrative Science Quarterly,* **38**, 51-73.

Ancona, D. G., P. S. Goodman, B. S. Lawrence and M. L. Tushman (2001), 'Time: a new research lens,' *Academy of Management Review,* **26**, 645-663.

Andriopoulos, C. and M. W. Lewis (2009), 'Exploitation-exploration tensions and organizational ambidexterity: managing paradoxes of innovation,' *Organization Science,* **20**, 696-717.

Benner, M. J. and M. L. Tushman (2003), 'Exploitation, exploration, and process management: the productivity dilemma revisited,' *Academy of Management Review,* **28**, 238-256.

Boumgarden, P., J. Nickerson and T. R. Zenger (2012), 'Sailing into the wind: exploring the relationships among ambidexterity, vacillation, and organizational performance,' *Strategic Management Journal,* **33**, 587-610.

Brown, S. L. and K. M. Eisenhardt (1997), 'The art of continuous change: linking complexity theory and time-paced evolution in relentlessly shifting organizations,' *Administrative Science Quarterly,* **42**, 1-34.

Burgelman, R. A. (2002), 'Strategy as vector and the inertia of coevolutionary lock-in,' *Administrative Science Quarterly,* **47**, 325-357.

Cao, Q., E. Gedajlovic and H. Zhang (2009), 'Unpacking organizational ambidexterity: dimensions, contingencies, and synergistic effects,' *Organization Science,* **20**, 781-796.

Dess, G. G. and D. W. Beard (1984), 'Dimensions of organizational task environments,' *Administrative Science Quarterly,* **29**, 52-73.

Duncan, R. B. (1972), 'Characteristics of organizational environments and perceived environmental uncertainty,' *Administrative Science Quarterly,* **17**, 313-327.

Eldredge, N. and S. J. Gould (1972), 'Punctuated equilibria: an alternative to phyletic gradualism,' in Schopf, T. (ed.), *Models in Paleobiology*. Freeman, Cooper: San Francisco, 82-115.

Ethiraj, S. K. and D. Levinthal (2004), 'Modularity and innovation in complex systems,' *Management Science,* **50**, 159-173.

Fang, C., J. Lee and M. A. Schilling (2010), 'Balancing exploration and exploitation through structural design: the isolation of subgroups and organizational learning,' *Organization Science,* **21**, 625-642.

Fang, C. and D. Levinthal (2009), 'Near-term liability of exploitation: exploration and exploitation in multistage problems,' *Organization Science,* **20**, 538-551.

Farjoun, M. (2007), 'The end of strategy?,' *Strategic Organization,* **5**, 197-210.

Floyd, S. W. and P. J. Lane (2000), 'Strategizing throughout the organization: managing role conflict in strategic renewal,' *Academy of Management Review,* **25**, 154-177.

Frenken, K. (2000), 'A complexity approach to innovation networks. the case of the aircraft industry (1909-1997),' *Research Policy,* **29**, 257-272.

Gavetti, G. and D. Levinthal (2000), 'Looking forward and looking backward: cognitive and experiential search,' *Administrative Science Quarterly,* **45**, 113-137.

Gavetti, G., D. A. Levinthal and J. W. Rivkin (2005), 'Strategy making in novel and complex worlds: the power of analogy,' *Strategic Management Journal,* **26**, 691-712.

Gersick, C. J. G. (1991), 'Revolutionary change theories: a multilevel exploration of the punctuated equilibrium paradigm,' *Academy of Management Review,* **16**, 10-36.

Gibson, C. B. and J. Birkinshaw (2004), 'The antecedents, consequences, and mediating role of organizational ambidexterity,' *Academy of Management Journal,* **47**, 209-226.

Gupta, A. K., K. G. Smith and C. E. Shalley (2006), 'The interplay between exploration and exploitation,' *Academy of Management Journal,* **49**, 693-706.

Hannan, M. T. and J. Freeman (1984), 'Structural inertia and organizational change,' *American Sociological Review,* **49**, 149-164.

Haveman, H. A. (1992), 'Between a rock and a hard place: Organizational change and performance under conditions of fundamental environmental transformation,' *Administrative Science Quarterly,* **37**, 48-75.

He, Z.-L. and P.-K. Wong (2004), 'Exploration vs. exploitation: An empirical test of the ambidexterity hypothesis,' *Organization Science,* **15**, 481-494.

Jansen, J. J. P., M. P. Tempelaar, F. A. J. van den Bosch and H. W. Volberda (2009), 'Structural differentiation and ambidexterity: the mediating role of integration mechanisms,' *Organization Science,* **20**, 797-811.

Jansen, J. J. P., F. A. J. Van Den Bosch and H. W. Volberda (2006), 'Exploratory innovation, exploitative innovation, and performance: effects of organizational antecedents and environmental moderators,' *Management Science,* **52**, 1661-1674.

Kauffman, S. A. (1993), *The Origins of Order: Self-Organization and Selection in Evolution.* Oxford University Press: New York.

Kim, T. and M. Rhee (2009), 'Exploration and exploitation: internal variety and environmental dynamism,' *Strategic Organization,* **7**, 11-41.

Klepper, S. (1997), 'Industry life cycles,' *Industrial and Corporate Change,* **6**, 145-182.

Knudsen, T. and D. A. Levinthal (2007), 'Two faces of search: alternative generation and alternative evaluation,' *Organization Science,* **18**, 39-54.

Kyriakopoulos, K. and C. Moorman (2004), 'Tradeoffs in marketing exploitation and exploration strategies: the overlooked role of market orientation,' *International Journal of Research in Marketing,* **21**, 219-240.

Lant, T. K. and S. J. Mezias (1992), 'An organizational learning-model of convergence and reorientation,' *Organization Science,* **3**, 47-71.

Lavie, D. and L. Rosenkopf (2006), 'Balancing exploration and exploitation in alliance formation,' *Academy of Management Journal,* **49**, 797-818.

Lavie, D., U. Stettner and M. L. Tushman (2010), 'Exploration and exploitation within and across organizations,' *Academy of Management Annals,* **4**, 109-155.

Lazer, D. and A. Friedman (2007), 'The network structure of exploration and exploitation,' *Administrative Science Quarterly,* **52**, 667-694.

Lenox, M. J., S. F. Rockart and A. Y. Lewin (2006), 'Interdependency, competition, and the distribution of firm and industry profits,' *Management Science*, **52**, 757-772.

Lenox, M. J., S. F. Rockart and A. Y. Lewin (2007), 'Interdependency, competition, and industry dynamics,' *Management Science,* **53**, 599-615.

Levinthal, D. A. (1997), 'Adaptation on rugged landscapes,' *Management Science,* **43**, 934-950.

Levinthal, D. A. and J. G. March (1993), 'The myopia of learning,' *Strategic Management Journal,* **14**, 95-112.

Levitt, B. and J. G. March (1988), 'Organizational learning,' *Annual Review of Sociology,* **14**, 319-340.

Lin, Z., Y. Haibin and I. Demirkan (2007), 'The performance consequences of ambidexterity in strategic alliance formations: empirical investigation and computational theorizing,' *Management Science,* **53**, 1645-1658.

Lubatkin, M. H., Z. Simsek, Y. Ling and J. F. Veiga (2006), 'Ambidexterity and performance in small-to medium-sized firms: the pivotal role of top management team behavioral integration,' *Journal of Management,* **32**, 646-672.

March, J. G. (1991), 'Exploration and exploitation in organizational learning,' *Organization Science,* **2**, 71-87.

Marengo, L., G. Dosi, P. Legrenzi and C. Pasquali (2000), 'The structure of problem-solving knowledge and the structure of organizations,' *Industrial and Corporate Change,* **9**, 757-788.

Miller, D. and P. H. Friesen (1980), 'Momentum and revolution in organizational adaptation,' *Academy of Management Journal*, **23**, 591-614.

Nadkarni, S. and V. K. Narayanan (2007), 'Strategic schemas, strategic flexibility, and firm performance: the moderating role of industry clockspeed,' *Strategic Management Journal,* **28**, 243-270.

O'Reilly, C. A. and M. L. Tushman (2008), 'Ambidexterity as a dynamic capability: resolving the innovator's dilemma,' *Research in Organizational Behavior,* **28**, 185-206.

Raisch, S. and J. Birkinshaw (2008), 'Organizational ambidexterity: antecedents, outcomes, and moderators,' *Journal of Management,* **34**, 374-409.

Raisch, S., J. Birkinshaw, G. Probst and M. L. Tushman (2009), 'Organizational ambidexterity: balancing exploitation and exploration for sustained performance,' *Organization Science,* **20**, 685-695.

Rindova, V. P. and S. Kotha (2001), 'Continuous "morphing": competing through dynamic capabilities, form, and function,' *Academy of Management Journal,* **44**, 1263-1280.

Rivkin, J. W. (2000), 'Imitation of complex strategies,' *Management Science,* **46**, 824-844.

Rivkin, J. W. (2001), 'Reproducing knowledge: replication without imitation at moderate complexity,' *Organization Science,* **12**, 274-293.

Rivkin, J. W. and N. Siggelkow (2003), 'Balancing search and stability: interdependencies among elements of organizational design,' *Management Science,* **49**, 290-311.

Rivkin, J. W. and N. Siggelkow (2007), 'Patterned interactions in complex systems: implications for exploration,' *Management Science,* **53**, 1068-1085.

Romanelli, E. and M. L. Tushman (1994), 'Organizational transformation as punctuated equilibrium: an empirical test,' *Academy of Management Journal,* **37**, 1141-1166.

Rothaermel, F. T. and D. L. Deeds (2004), 'Exploration and exploitation alliances in biotechnology: a system of new product development,' *Strategic Management Journal,* **25**, 201-221.

Sabherwal, R., R. Hirschheim and T. Goles (2001), 'The dynamics of alignment: insights from a punctuated equilibrium model,' *Organization Science,* **12**, 179-197.

Sanchez, R. and J. T. Mahoney (1996), 'Modularity, flexibility, and knowledge management in product and organization design,' *Strategic Management Journal,* **17**, 63-76.

Sastry, M. A. (1997), 'Problems and paradoxes in a model of punctuated organizational change,' *Administrative Science Quarterly,* **42**, 237-275.

Schildt, H. A., M. V. J. Maula and T. Keil (2005), 'Explorative and exploitative learning from external corporate ventures,' *Entrepreneurship Theory and Practice*, **29**, 493-515.

Schilling, M. A. and H. K. Steensma (2001), 'The use of modular organizational forms: an industry-level analysis,' *Academy of Management Journal,* **44**, 1149-1168.

Siggelkow, N. (2001), 'Change in the presence of fit: the rise, the fall, and the renaissance of Liz Claiborne,' *Academy of Management Journal*, **44**, 838-857.

Siggelkow, N. (2002), 'Evolution toward fit,' *Administrative Science Quarterly,* **47**, 125-159.

Siggelkow, N. and D. A. Levinthal (2003), 'Temporarily divide to conquer: centralized, decentralized, and reintegrated organizational approaches to exploration and adaptation.,' *Organization Science,* **14**, 650-669.

Siggelkow, N. and J. W. Rivkin (2005), 'Speed and search: designing organizations for turbulence and complexity,' *Organization Science,* **16**, 101-122.

Siggelkow, N. and J. W. Rivkin (2006), 'When exploration backfires: unintended consequences of multilevel organizational search,' *Academy of Management Journal,* **49**, 779-795.

Simons, A. M. (2002), 'The continuity of microevolution and macroevolution,' *Journal of Evolutionary Biology*, **15**, 688-701.

Simsek, Z., C. Heavey, J. F. Veiga and D. Souder (2009), 'A typology for aligning organizational ambidexterity's conceptualizations, antecedents, and outcomes,' *Journal of Management Studies*, **46**, 864-894.

Smith, W. K., A. Binns and M. L. Tushman (2010), 'Complex business models: managing strategic paradoxes simultaneously,' *Long Range Planning*, **43**, 448-461.

Sommer, S. C. and C. H. Loch (2004), 'Selectionism and learning in projects with complexity and unforeseeable uncertainty,' *Management Science,* **50**, 1334-1347.

Tushman, M. L. and P. Anderson (1986), 'Technological discontinuities and organizational environments,' *Administrative Science Quarterly,* **31**, 439-465.

Tushman, M. L., W. H. Newman and E. Romanelli (1986), 'Convergence and upheaval: managing the unsteady pace of organizational evolution,' *California Management Review,* **29**, 29-44.

Tushman, M. L. and C. A. O'Reilly (1996), 'Ambidextrous organizations: managing evolutionary and revolutionary change,' *California Management Review,* **38**, 8-30.

Tushman, M. L. and E. Romanelli (1985), 'Organizational evolution: a metamorphosis model of convergence and reorientation,' in Cummings, L. L. and Staw, B. M. (ed.), *Research in Organizational Behavior,* Vol. **7**. JAI Press: Greenwich, CT, 171-222.

Uotila, J., M. Maula, T. Keil and S. A. Zahra (2009), 'Exploration, exploitation, and financial performance: analysis of S&P 500 corporations,' *Strategic Management Journal,* **30**, 221-231.

Venkatraman, N., C.-H. Lee and B. Iyer (2007), Strategic ambidexterity and sales growth: a longitudinal test in the software sector (working paper). Boston: Boston University.

Volberda, H. W. (1996), 'Toward the flexible form: how to remain vital in hypercompetitive environments,' *Organization Science,* **7**, 359-374.

Wang, H. and J. Li (2008), 'Untangling the effects of overexploration and overexploitation on organizational performance: the moderating role of environmental dynamism,' *Journal of Management,* **34**, 925-951.

Wiersema, M. F. and K. A. Bantel (1993), 'Top management team turnover as an adaptation mechanism: the role of the environment,' *Strategic Management Journal,* **14**, 485-504.

Wischnevsky, J. D. and F. Damanpour (2005), 'Punctuated equilibrium model of organizational transformation: sources and consequences in the banking industry,' in Woodman, R. W. and Pasmore, W. A. (ed.), *Research in Organizational Change and Development*, Vol. **15**. Elsevier: New York, 207-239.

Wollin, A. (1999), 'Punctuated equilibrium: reconciling theory of revolutionary and incremental change,' *Systems Research and Behavioral Science,* **16**, 359-367.

Worren, N., K. Moore and P. Cardona (2002), 'Modularity, strategic flexibility, and firm performance: a study of the home appliance industry,' *Strategic Management Journal,* **23**, 1123-1140.

Figure 1. Adaptation process in a simple and slow-moving landscape (K = 0, T = 0.005).

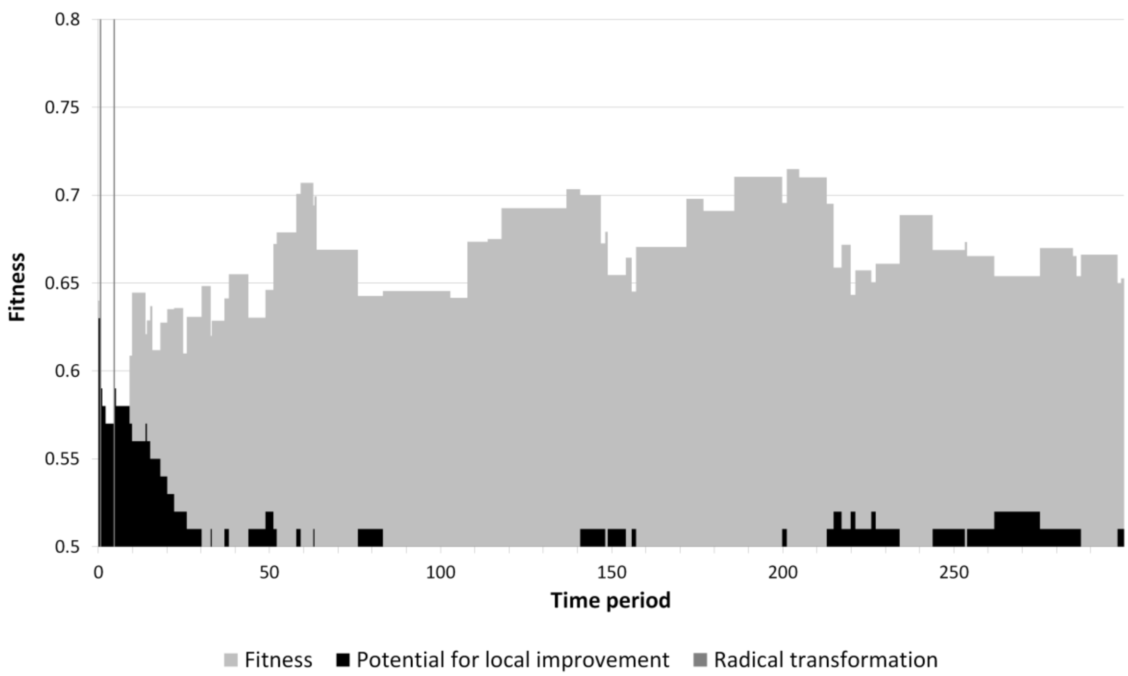


Figure 2. Adaptation process in a simple and fast-moving landscape (K = 0, T = 0.025).

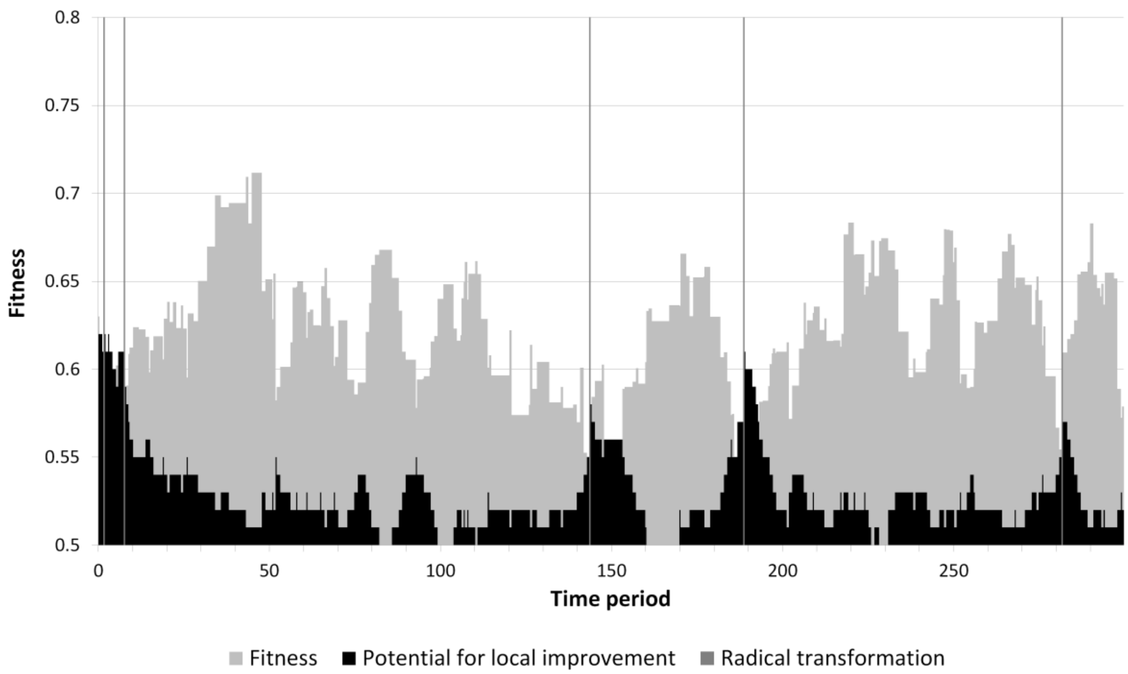


Figure 3. Adaptation process in a complex and slow-moving landscape (K = 16, T = 0.005).

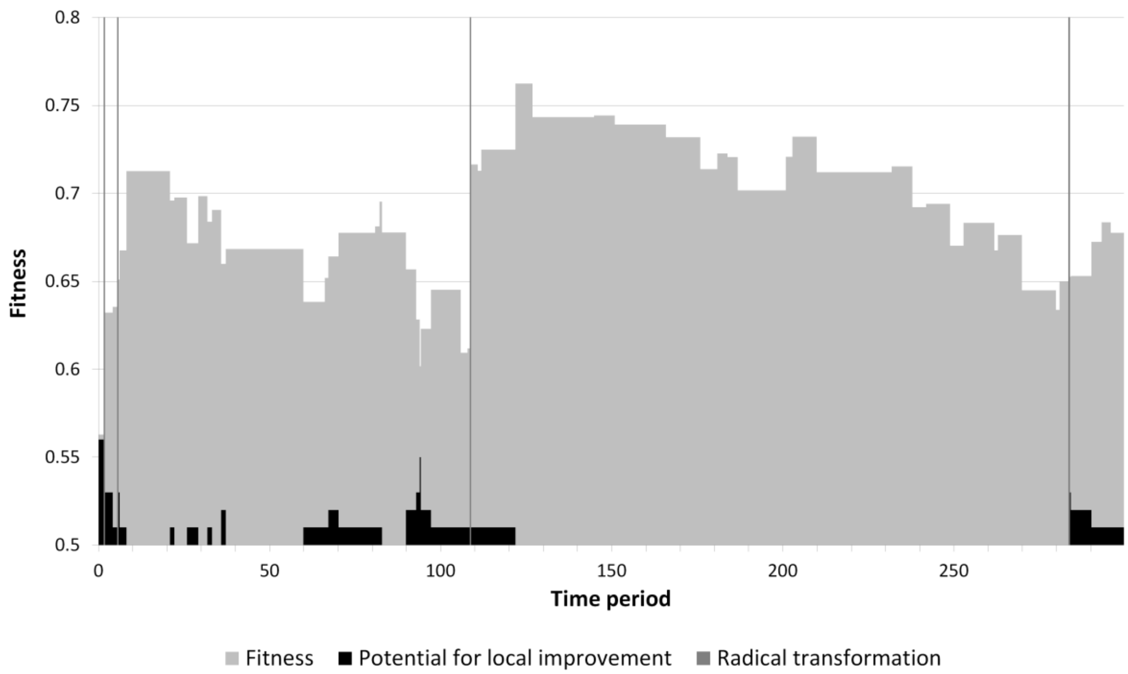


Figure 4. Adaptation process in a complex and fast-moving landscape (K = 16, T = 0.025).

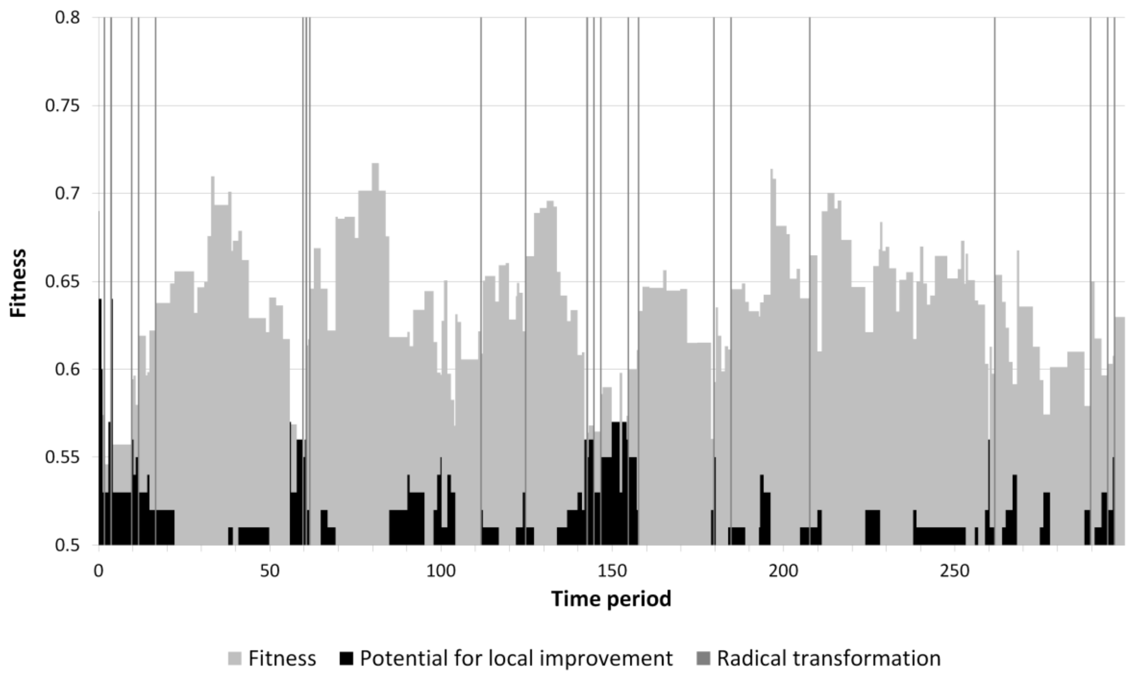
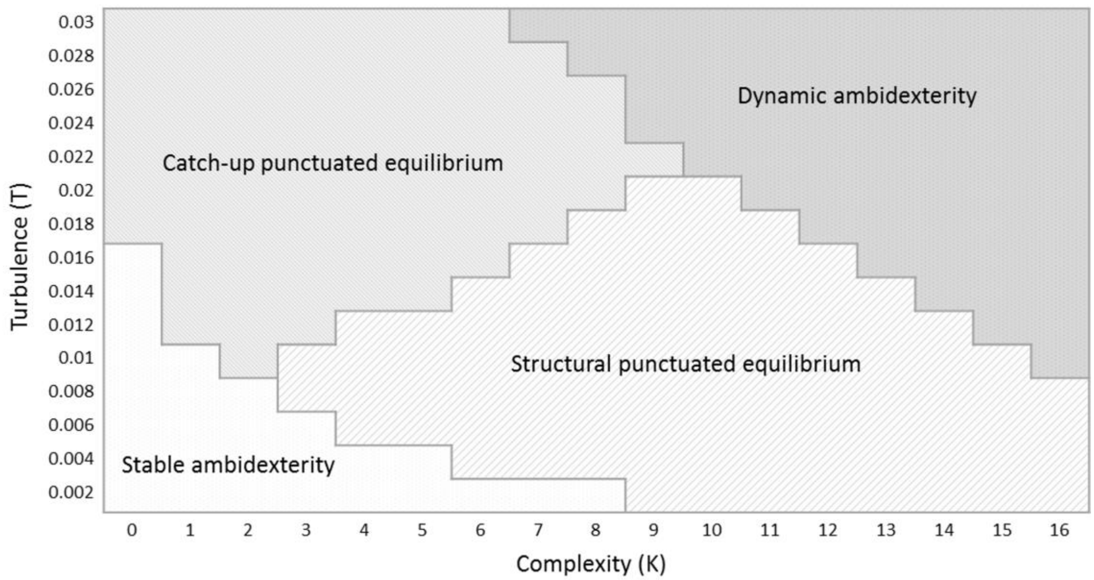


Figure 5. Adaptation regimes with different values of complexity and turbulence.



	Categorization rules	
	Probability of radical transformation per time period	*Average potential for local improvement when radical transformation occurs*
Stable ambidexterity	Less than 0.004	Any
Catch-up punctuated equilibrium	From 0.004 to 0.030	2 or more
Structural punctuated equilibrium	From 0.004 to 0.030	Less than 2
Dynamic ambidexterity	More than 0.030	Any

Figure 6. Balancing Exploration and Exploitation in Different Task Environments.

Complexity \ Turbulence	Low	High
Low	Stable Ambidexterity Organizations are able to keep pace with the environment through continuous incremental adaptation. Large-scale transformation occurs as a slow accumulation of incremental adaptive steps over time.	Catch-Up Punctuated Equilibrium The rate of environmental change is too fast for incremental adaptation alone to be sufficient in the long term. Occasional radical transformation is needed to catch up with rapidly accumulating environmental demands.
High	Structural Punctuated Equilibrium Organizations get stuck on locally optimal choice configurations due to task interdependencies. Occasional radical transformation is needed to escape these local peaks when the accumulation of environmental change makes these peaks suboptimal.	Dynamic Ambidexterity Interdependencies limit the potential for incremental adaptation, and local peaks are quickly destroyed by environmental turbulence. Organizations constantly engage in both incremental and radical changes in search for temporary local peaks.

[1] Some scholars use the terms “sequential ambidexterity” (Simsek et al., 2009; Venkatraman et al., 2007) or “vacillation” (Boumgarden et al., 2012) to denote the pattern of temporal cycling between exploration and exploitation. In this paper, I follow Gupta et al. (2006) and Raisch and Birkinshaw (2008) and define ambidexterity as the simultaneous pursuit of exploration and exploitation and therefore as distinct from the punctuated equilibrium model.

[2] The key features of the NK model are not qualitatively sensitive to the number of potential values for each choice element (Kauffman, 1993); thus, it is customary to limit these values to 0 or 1.

[3] To some degree, organizations can be argued to be able to influence the interdependencies between their decision elements by adopting different organizational structures (e.g. Schilling and Steensma, 2001). Because a closer analysis of organizational structure falls outside the scope of this paper, for the purposes of the analysis, I assume that the degree of interdependencies between the tasks is an exogenously given characteristic of the task environment.

[4] With N environmental dimensions, each of which changes with the probability T, the probability that at least one dimension changes is $1-(1-T)^N$. When N = 20 and T = 0.005, this probability is $1-0.995^{20} = 0.095$.

[5] The number of iterations (100) was chosen based on an evaluation of the point at which the simulation results began to converge such that any larger number of iterations would yield qualitatively similar results.

[6] Because of the lack of a dynamic need to balance exploration and exploitation, whether such a stable change pattern should be labeled “ambidexterity” in the first place is debatable. Here, I use the term to denote the pattern in which the organization is able to fulfill both its short-term and long-term adaptive needs without temporally separating the two.